ORIGINAL ARTICLE

Assessment of anterior chamber angles for detecting eyes with narrow angles: An anterior segment OCT Study

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Abstract

Objective: The detection of eyes with narrow angles in respect to an anterior chamber angles with anterior segment optical coherence tomography.

Study design: Retrospective observational study

Setting and duration: This study was conducted at Civil hospital Karachi-Pakistan from September 2017 to October 2018.

Material and Methods: Medical and ophthalmic history with shallow anterior chamber on slit lamp evaluation were obtained. Anterior segment imaging by AS-OCT, anterior chamber depth, axial length (mm) measurements and intraocular pressure (IOP, mmHg) were noted. Refractive status was recorded as patients with hyper-matrop and myopia. Nasal and temporal angles were evaluated. The algorithm then automatically calculated following angle measurements: angle opening distance (AOD), angle recess area (ARA), and trabecular-iris space area (TISA).

Results: Total of 58 eyes of 32 patients were observed into this study. Of these, 23(39.7%)were males and 35(60.3%)were females. The mean ± SD age was 56.23±7.4 years. The mean ± SD of IOP (mmHg) was 14.6±2.5, axial length (mm) 22.32±1.21 and central ACD (mm) 3.24±0.43. The AUCs were highest for AOD750 (0.89) in nasal quadrant and (0.88) in temporal quadrants. The AUCs for ARA750/ TISA750 in the nasal quadrants were 0.79/0.85 and temporal quadrants were 0.80/0.87. At 225 and 258 µm cutoff values of AOD750, the highest AUCs of sensitivity and specificity were observed for both nasal quadrants and temporal quadrants.

Conclusions: AS-OCT is more sensitive in identifying narrow angles with good repeatability and reproducibility. Either, it has low specificity, but, it has a significant impact as the new posterior segment imaging device.

Keywords: AS-OCT, glaucoma, nasal quadrants, temporal quadrants, angle recess area (ARA) trabecular-iris space area (TISA), angle opening distance (AOD)

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Introduction:

Glaucoma is a progressive optic neuropathy characterized by structural changes in the optic nerve head with corresponding changes in the visual field. Glaucoma is the second leading cause of blindness after cataract worldwide. Narrow angles of the eye may be a precursor to anterior chamber glaucoma (ACG) and a careful evaluation of the angles is valuable in identifying those at risk. While the final pathway involving structural and functional loss is similar for various types of glaucoma, a comprehensive evaluation of the drainage angle is critical for accurate diagnosis and appropriate therapeutic intervention.

In the United States, the most common type of glaucoma is primary open-angle glaucoma, whereas primary angle-closure glaucoma is the major form in other parts of the world. Many patients may present with narrow or occludable angles without any other abnormality; some may have primary angle closure with peripheral anterior synechiae and/or elevated intra-ocular pressure; yet others may have primary angle-closure glaucoma with optic nerve damage. Furthermore, forces at different anatomic levels in the eye may be responsible for the pathogenesis of angle closure: the iris (pupillary block), the ciliary body (plateau iris), the lens (phacomorphic glaucoma), and posterior to the lens (malignant glaucoma).

The current gold standard in assessing anterior chamber angles is the gonioscopy which is subjective. More objective techniques like the Anterior Segment Optical Coherence Tomography (AS-OCT), pentacam, ultrasound bio-microscopy are also being assessed for their reliability. AS-OCT uses light to produce high resolution cross-sectional images of anterior chamber angle (ACA). It uses low coherence interferometry to measure delay of light reflected from tissue structures and compares with light from reference mirror by using Michelson-type interferometer. Spectral Domain OCT (SD-OCT) uses 830nm wave length of light and fixed reference mirror allowing for higher scanning speed and more images to be taken in a single pass.

The AS-OCT provides an objective method to assess the anterior segment of the eye, including the anatomy of the anterior chamber angle. This technology allows both qualitative and quantitative analyses of the angle and has shown potential in detecting and managing angle-closure glaucoma. In addition, it has a role in identifying pathology in some forms of secondary open-angle glaucoma and post-surgical management of glaucoma. Therefore, the assessment of diagnostic performance of quantitative AS-OCT angle measurements for detecting narrow angle eyes is the main objective of this study.

Materials and Methods:

This retrospective observational study was conducted at Civil hospital Karachi-Pakistan from September 2017 to October 2018. Medical records of patients visited to outpatient department (OPD) or admitted to ward with shallow anterior chamber on slit lamp evaluation were recruited. Patients reporting above the age of 30 with no history of intra-ocular surgery/procedure, with healthy cornea and no anterior segment inflammation with peripheral Anterior Chamber Depth (ACD, mm) of grade 2 or less by Van Herick's technique were included in this study. For each study subject, medical and ophthalmic history were obtained. Each participant underwent the following examinations on visual acuity, anterior segment imaging by AS-OCT, anterior chamber depth, axial length (mm) measurements and intra-ocular pressure (IOP, mmHg). Refractive status was recorded as patients with hyper-matropia and myopia. Nasal and temporal angles were evaluated and maintained vertically for assessing superior and inferior angles.

Patients were excluded if they had a history of intra-ocular surgery, any evidence of aphakia/pseudophakia, or penetrating trauma in the eye; previous anterior segment laser treatment; a history of glaucoma; or corneal disorders such as corneal endothelial dystrophy, corneal opacity, or pterygium, all of which could influence the quality of angle imaging by AS-OCT., Eyes diagnosed with asymmetrical laterality were also excluded from this study. Anterior segment imaging was obtained using a commercially available AS-OCT (Nidec RS-3000 OCT Retina Scan Advance 2). For AS-OCT, the principle of low-coherence interferometry instead of ultrasound to produce high-resolution, cross-sectional images of the anterior segment of the eye was used. After acquisition, the scanned images are processed by a customized ("dewarping") software that compensates for index of refraction transition at the air-tear interface and the different indices in air, cornea, and aqueous humor to correct the physical dimensions of the images. AS-OCT images of the anterior chamber angle of each eye were obtained in dark conditions using the single-scan-mode protocol: one image scanning the angle at the 3- and 9-O'clock positions (horizontal meridian) followed by one scanning the superior angle at 12 O'clock and one scanning the inferior angle at 6 O'clock. The Zhongshan Angle Assessment Program (ZAAP; Zhongshan Ophthalmic Centre, Guangzhou, China) was used to analyze the AS-

Table-1: Patients baseline characteristics

Characteristics	Results
No. of eyes	58
Gender	
Males	23(39.7%)
Females	35(60.3%)
Laterality of both eyes	52(89.7%)
Lateralityonly Right eye	4(6.9%)
Lateralityonly Left eye	2(3.4%)
Mean age of patients (years)	56.23±7.4
IOP (mmHg)	14.6±2.5
Axial length (mm)	22.32±1.21
Central ACD (mm)	3.24 ± (0.43)
Refractive status	
Hypermatrop	39(67.2%)
Myopia	12(20.7%)

Abbreviation: ACD, anterior chamber depth; IOP, intraocular pressure
Data presented as mean ± SD or n (%)

Table-2: AUC for mean quantitative angle measurements in the detection of angle closure

Measurement	Nasal Quadrant AUC (95% CI)	Temporal Quadrant AUC (95% CI)
AOD250	0.79 (0.78-0.80)	0.77 (0.76-0.79)
AOD500	0.82 (0.80-0.85)	0.86 (0.87-0.89)
AOD750	0.89 (0.89-0.92)	0.88 (0.89-0.93)
ARA750	O.79 (0.81-0.85)	0.80 (0.82-0.86)
TISA500	0.80 (0.79-0.82)	0.82 (0.79-0.84)
TISA750	0.85 (0.84-0.86)	0.87 (0.86-0.89)

AOD: angle opening distance; ARA, angle recess area; TISA, trabecular-iris space area AUC, area under the receiver operating characteristics curve; CI, confidence interval; Numbers (250, 500, and 750) indicate the distance in micrometers from the scleral spur, With high AUC, boldface type signifies measurement

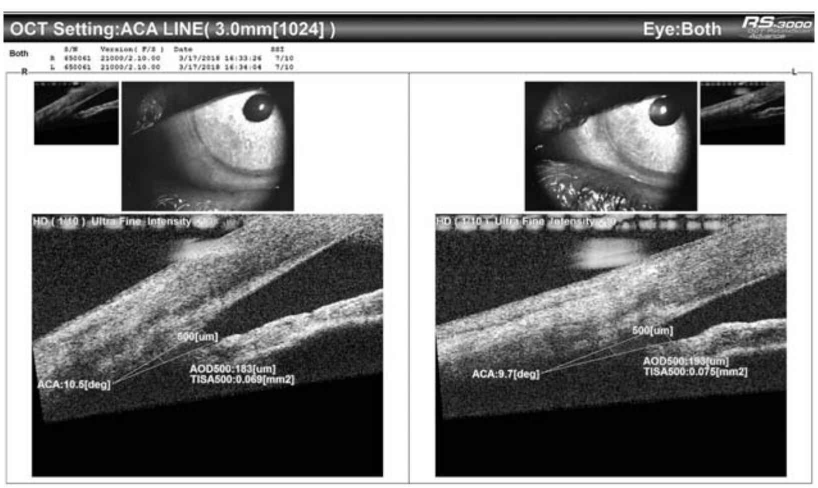

Figure-1: (a) Closed angle image by AS-OCT

OCT images for quantitative measurements. For each image, the only observer input was to determine the location of the 2 scleral spurs. The algorithm then automatically calculated the following angle measurements: angle opening distance (AOD), angle recess area (ARA), and trabecular-iris space area (TISA). Angle opening distance was defined as the length of a line drawn from the anterior iris to the corneal endothelium, perpendicular to a line drawn along the trabecular meshwork at a given distance from the scleral spur. The AOD was calculated at AOD250, AOD500, and AOD750 μm from the scleral spur. The ARA was calculated at 750 μm (ARA750), and the TISA was calculated at 500 and 750 μm (TISA500 and TISA750, respectively). Thus, the quantitative analysis of this study evaluated only the horizontal scan.

The ARA represents measurement of the area bordered by the anterior iris surface, corneal endothelium, and a line perpendicular to the corneal endothelium that is drawn to the iris surface from a point ARA750 μm anterior to the scleral spur. The TISA is a measurement that is further modified by not including the area below a line drawn from the scleral spur to the anterior iris perpendicular to the plane of the inner scleral wall. Normal angle was defined as the anterior chamber angle refers to the junction between the iris root and cornea. In evaluating the angle, an important anatomic landmark is the scleral spur, which is the connecting point between the posterior curvature of the cornea and the curvature of the sclera. If the iris is posterior to the scleral spur, the angle is open. If the iris is anterior to the scleral spur, the angle is either narrow or closed.

Data was analyzed using statistical package for social science (SPSS) version 20. Data was presented as mean±SD and number (%). Chi-square test, sensitivity, specificity, positive and negative predictive value used to find correlation between OCT parameters. P-value was defined significance at P>0.05.

Results:

Total of 58 eyes of 32 patients were observed into this study. Of these, 23(39.7%) were males and 35(60.3%) were females. Laterality of both eyes were 52(89.7%), laterality of only right

Table-3: Nasal and Temporal quadrants vs diagnostic statistical measures for quantitative angle closure measurement

Measurement	Sensitivity	Specificity	PPV	NPV	AUC
Nasal Quadrant					
AOD250≤138µm	66.4 (0.78-0.80)	71.3 (0.76-0.79)	31.5 (0.78-0.80)	82.6 (0.76-0.79)	0.77 (0.76-0.79)
AOD500≤177 µm	72.3 (0.80-0.85)	76.9 (0.87-0.89)	32.7 (0.80-0.85)	91.2 (0.87-0.89)	0.81 (0.87-0.89)
AOD750≤225 µm	82.1 (0.89-0.92)	80.8 (0.89-0.93)	35.4 (0.89-0.92)	93.8 (0.89-0.93)	0.86 (0.89-0.93)
ARA750≤76 µm2	79.6 (0.81-0.85)	72.6 (0.82-0.86)	29.7 (0.81-0.85)	88.8 (0.82-0.86)	0.73 (0.82-0.86)
TISA500≤134 µm2	80.7 (0.79-0.82)	73.5 (0.79-0.84)	30.8 (0.79-0.82)	84.7 (0.79-0.84)	0.79 (0.79-0.84)
TISA750≤154 µm2	78.5 (0.84-0.86)	75.8 (0.86-0.89)	30.5 (0.84-0.86)	89.6 (0.86-0.89)	0.71 (0.86-0.89)
Temporal Quadrant					
AOD250≤144 µm	79.7 (0.78-0.80)	70.9 (0.76-0.79)	24.8 (0.78-0.80)	90.3 (0.76-0.79)	0.75 (0.76-0.79)
AOD500≤191 µm	77.3 (0.80-0.85)	71.8 (0.87-0.89)	29.6 (0.80-0.85)	90.4 (0.87-0.89)	0.81 (0.87-0.89)
AOD750≤258 µm	86.7 (0.89-0.92)	73.3 (0.89-0.93)	32.3 (0.89-0.92)	97.6 (0.89-0.93)	0.82 (0.89-0.93)
ARA750≤103 µm2	80.3 (0.81-0.85)	61.4 (0.82-0.86)	21.6 (0.81-0.85)	91.5 (0.82-0.86)	0.79 (0.82-0.86)
TISA500≤151 µm2	82.5 (0.79-0.82)	69.8 (0.79-0.84)	28.8 (0.79-0.82)	93.6 (0.79-0.84)	0.80 (0.79-0.84)
TISA750≤191 µm2	78.9 (0.84-0.86)	66.5 (0.86-0.89)	31.5 (0.84-0.86)	94.5 (0.86-0.89)	0.76 (0.86-0.89)

AOD: angle opening distance; ARA, angle recess area; TISA, trabecular-iris space area; PPV, positive predictive value; NPV, negative predictive value; AUC, area under the receiver operating characteristics curve; CI, confidence interval; Numbers (250, 500, and 750) indicate the distance in micrometers from the scleral spur, With high AUC, boldface type signifies measurment

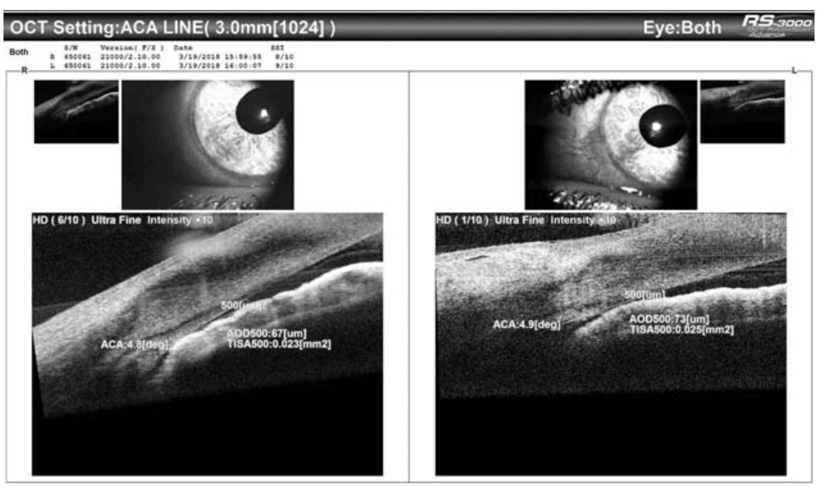

Figure-1: (b) Closed angle image by AS-OCT
AOD = angle opening distance; ARA = angle recess area; and TISA= trabecular-iris space area

eyes was 4(6.9%) and laterality of only left eyes were 2(3.4%). The mean±SD age was 56.23±7.4 years. Refractive status show that patients with hyper-matropia were 39(67.2%) wand myopia 12(20.7%). The mean±SD of IOP (mmHg) was 14.6±2.5, axial length (mm) 22.32±1.21 and central ACD (mm) 3.24±0.43 (table-1).

58 eyes were diagnosed as having narrow angles on AS-OCT. AUC (95% CI) for mean quantitative angle measurements in the detection of angle closure for Nasal Quadrant and Temporal Quadrant was shown in table-2. The AUCs were highest for AOD750 in the nasal (0.89 [95% CI, 0.89-0.92]) and temporal (0.88 [95% CI, 0.89-0.93]) quadrants followed by AOD500(0.82 [95% CI, 0.80-0.85]) and (0.86 [95% CI, 0.87-0.89]), respectively. The AUCs for ARA750 in the nasal quadrants were (0.79 [95% CI, 0.81-0.85]) and temporal quadrants were (0.80 [95% CI, 0.82-0.86]). Meanwhile, the AUCs for TISA750 in the nasal and temporal quadrants were (0.85 [95% CI, 0.84-0.86]) and (0.87 [95% CI, 0.86-0.89]), respectively.

The uppermost AUCs of Nasal and Temporal quadrants vs diagnostic statistical measures for quantitative angle closure measurements with various cutoffs are shown in table-3. At 225 and 258 µmcutoff values of AOD750,the highest AUCs of specificity were observed for both nasal quadrants (80.8 [95% CI, 0.89-0.93]) and temporal quadrants (73.3 [95% CI, 0.89-0.93]).

Figure-1a and 1b showing closed angle image by AS-OCT. Schematic representation of areas and distances used as specifications of quantitative angle measurements by AS-OCT was shown in figure-2.

Discussion:

In our study, AS-OCT quantitative angle measurements for detecting eyes with narrow angles performed better, in the nasal quadrant and temporal quadrant with AUC values of 0.89 and 0.88 for AOD750. Our results are consistent to Narayanaswamy A et al.,[11] study that showed the AUC values of 0.90 in nasal quadrant and 0.91 in temporal quadrant for AOD750. AS-OCT is more sensitive in identifying narrow angles similar to Li H et al[12] study. It is envisioned that it has a significant impact as the new posterior segment imaging device.

AS-OCT scans with higher-resolution show

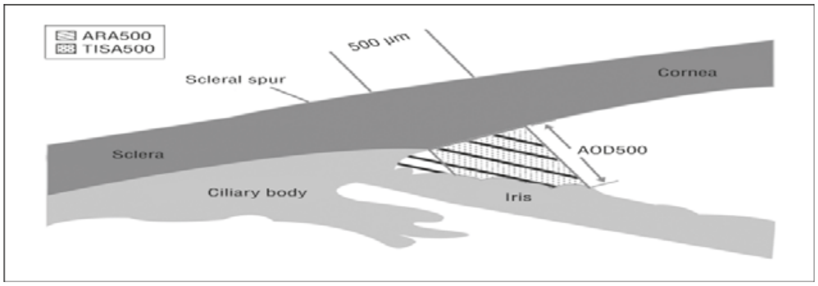

Figure-2: Schematic representation of areas and distances used as specifications of quantitative angle measurements by anterior segment optical coherence tomography

the images with better scleral spur localization. Correction of refraction of the air, cornea, and aqueous humor and other related advancement in existing technology may improve the rate of scleral spur identification, which will improve the performance of AS-OCT. The ARA and TISA measurements were proposed to overcome this potential error; however, in our study, ARA750 had relatively low AUCs (95% CI) 0.79 (0.81-0.85) / 0.80(0.82-0.86) 0.83/0.84, for nasal/temporal quadrants as compare to AUCs of TISA750: 0.85 (0.84-0.86)/0.87 (0.86-0.89) for nasal/temporal quadrants. The major advantages of this device is the non-contact nature of examination, high scan speed, good repeatability and reproducibility for quantitative and qualitative measurements, and cross-sectional visualization of anterior segment structures that all the essential parameters in detecting angle closure/narrow angle were examined in a single scan and could well be the start of a new era for ophthalmic diagnosis similar to Dorairaj S et al.,[13] study. As a result, it is a quick, easily tolerated procedure for the patient and there is also less distortion of angle morphology due to lack of globe manipulation similar to Sakata LM et al.,[14] study. Chronic angle closure was observed in Asians and they do not visit clinical attention until severe ocular damage has already occurred. In contrast, narrow angles were detected more in older population and in women compared to men in our study, consistent with other reports in multiple populations. The most likely explanations for a higher prevalence of angle closure glaucoma among older persons are the increase in lens thickness that occurs with age. This leads to crowding of the anterior segment and postulated that the zonules becomes more with age, allowing the anterior movement of the lens-iris diaphragm similar to Nolan WP et al[17] study. Either AS-OCT quantitative analysis is more helpful for patient'seyes at risk of angle closure with number of advantages, but still the location of the scleral spur is difficult to detectis an important drawback which limit its use for population screening. Overall, the diagnostic performance of the AS-OCT observed in this study may better reflect its performance in a real-life population-based setting.

Limitations: Small sample size remains the limitations of our study. Similar study on more number of patients, is require to provide definitive answer. Also, the scleral spur of superior and inferior quadrants could not be identified in the model of the OCT.

Conclusions:
AS-OCT is more sensitive in identifying narrow angles with good repeatability and reproducibility in this study. Either, it has low specificity, but, it has a significant impact as the new posterior segment imaging device in detecting angle closure.

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Role and contribution of authors:
Dr. Sharjeel Sultan, concept and design, undertook the data analyses, wrote, edited and approved the manuscript

Dr. A. Rasheed Khokar, concept and design, Interpretation of data, Reviewed and approved the manuscript

Mrs. Nazish Waris, interpretation of data, wrote, edited and reviewed the manuscript

Dr. Nisar A. Siyal, Concept and design, reviewed and approved the manuscript

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